33d Congress, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 56.

WROUGHT-IRON BEAMS.

LETTER

FROM THE

SECRETARY OF THE TREASURY,

TRANSMITTING

Results of experiments made to test the strength of wrought-iron beams, &c.

February 6, 1855.—Referred to the Committee of Ways and Means, and ordered to be printed.

Treasury Department,
February 1, 1855.

Sir: The law of the last session of Congress appropriating money for the erection of certain buildings to be used as custom-houses, United States courts, post offices, &c., requires them to be fire-proof. In carrying out this wise provision of the act, it has become necessary to use wrought-iron in very large quantities, and in combinations hitherto untried. Wrought-iron beams are now rolled of such sizes and lengths that, by combinations with made wrought-iron girders, they can be adapted to the largest-sized buildings. The economy of using this material instead of cast metal is equal to its greater security.

At the request of this department, the enterprising and public-spirited proprietors of the only establishment where the heavy beams are rolled, instituted a series of experiments for testing, on a limited scale, the strength of these beams and girders. I communicate herewith the results as ascertained by an officer sent by this department to witness the experiments. The very large amount of rolled iron required in the construction of buildings now authorized by Congress, renders it desirable that a more extended series of experiments should be made. To secure the requisite stability, the beams and girders of a fire-proof floor should not be placed too far apart, while economy forbids that more than are necessary should be used. To show the importance of accurate information on this point, I beg to state that, in the smallest-sized building authorized by Congress at its last ses-

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

sion for custom-houses, an increase of six inches in the space between each two beams, *decreases* the cost of building $1,724 80.

It is proper to state that the beams now being used are entirely new to builders, and hence the absence (except the limited experiments herewith enclosed) of practical knowledge of their capacity.

In view of the importance of this subject to the economical expenditure of the money placed at the disposal of this department for the buildings in question, as well as the interest builders generally feel on the subject, I beg leave respectfully to suggest that an appropriation of three thousand five hundred dollars be made to meet the expense of a complete series of experiments to test the strength of wrought-iron beams and girders of all dimensions required in the structures above referred to.

It is also proper to add, that the liberal owners of the rolling-mill have offered samples of the various sized beams and girders for the proposed tests, free of charge to the government.

I have the honor to be, very respectfully,

JAMES GUTHRIE,
Secretary of the Treasury.

Hon. LINN BOYD,
Speaker of the House of Representatives.

EXPERIMENT No. 1.

Rectangular girder of wrought iron, 20′ 3″ long, 19′ 5″ between supports, as per drawing—figures 1, 2, 3, *and* 4, *and section figure* 11.

Date.	No of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
1854.		*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	
Oct. 20	1	8,500	8,500	.125	Not taken.	
20	2	4,490	12,990	.1875	....do.....	
20	3	6,730	19,720	Not taken.	....do.....	
21	4	4,510	24,230	.25	....do.....	
21	5	4,514	28,744	.4375	....do.....	
21	6	4,538	33,282	.5	....do.. ...	
21	7	4,562	37,844	.5625	.037	(Ex. 7, R. No. 1.)
21	8	4,543	42,387	.625	Not taken.	
21	9	4,536	46,923	.6875	....do.....	
21	10	4,537	51,460	.75	....do.....	
21	11	4,525	55,985	.8125	....do.....	
21	12	4,568	60,553	.9375	....do.....	
21	13	4,536	65,089	1.2187	....do.....	
21	14	4,663	69,752	1.4375	....do.....	
23	15	7,110	76,862	1.5	....do.....	(Ex. 15, R. No. 2.)
Nov. 9	16	.....	76,862	1.5	....do.....	
Dec. 20	17	.....	76,862	1.625	....do.....	(Ex. 17, R. No. 3.)
20	18	4,480	81,342	1.6875	....do.....	
20	19	4,480	85,822	1.9375	....do.....	(Ex. 19, R. No. 4.)
20	20	.....	85,822	2.3125	....do.....	
20	21	.....	85,822	2.4375	....do.....	
20	22	4,480	90,302	3.4375	....do.....	(Ex. 22, R. No. 5.)
20	23	.....	90,302	3.5	....do.....	
20	24	.....	90,302	4.1875	....do.....	

Section of wrought-iron truss-girder.

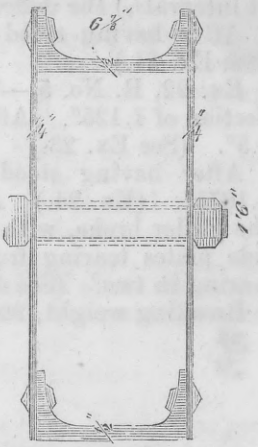

Fig. 11.

Ex. 7, R. No. 1.—Weight all removed, showing a permanent deflection of .0937″. The same load was then applied again, (37,844 pounds,) and 4,543 pounds were added.

Ex. 15, R. No. 2.—The beam stood with this load (76,862 pounds) until December 20. It was measured November 9.

Ex. 17, R. No. 3.—December 20, 9 a. m., thermometer 5° above zero. Mr. Cooper is of the opinion that this settlement of .125″ was due to an inaccuracy in the straight-edge, it having been exposed from November 9 to December 20, and the position of the points of support he thinks may have been changed.

Mr. Cooper may be right in his opinion. It will be safer, however, to suppose that the increased deflection arose from the extreme cold weather, or from the oscillation of the table, preparatory to adjusting it for the reception of the additional weights.

It having been apprehended that the girder might yield to lateral flexure, if the seven bolts connecting the side-plates were removed, the nuts of these bolts were accordingly unscrewed at Ex. 17, but there was no increase of deflection.

Ex. 19, R. No. 4.—With this weight (85,822 pounds) a cracking noise was perceptible, which was evidently the tearing or crushing of the fibres of the iron.

After having stood ten minutes, (the cracking noise still continuing at intervals,) the deflection was 2.3125″. (See Ex. 20.)

After having stood one hour longer, the deflection was 2.4375″. (See Ex. 21.)

Ex. 22, R. No. 5.—This load (90,302 pounds) produced a side deflection of 1.125″. After having stood ten minutes the deflection was 3.5″. (See Ex. 23.)

After having stood twenty minutes longer, the deflection was 4.1875″. (Ex. 24.) After having stood twenty-five minutes longer, the girder broke, with two sharp successive reports, evidently by the side plates tearing from their bottom edges, and the bottom plate tearing in two. (See drawing, Figs. 2, 3, and 4.)

Breaking weight, 90,302 pounds, suspended on the centre.

EXPERIMENT No. 2.

Experiment on a beam as per section, figure 12, *sixteen feet between supports.*

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
1854.		*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	
Dec. 21	1	2,240	2,240	.0937	0	
	2	2,240	4,480	.1875	0	
	3	2,240	6,720	.5625	.0625	
	4	2,240	8,960	.7187	.125	
	5	2,240	11,200	1.25	.375	
	6	2,240	13,440	.....	.....	Ex. 6, R. No. 1.

Ex. 6, R. No. 1.—The beam bent laterally until the scales containing the weight struck the ground. No sign of fracture.

EXPERIMENT No. 3.

Experiment on a beam exactly like the foregoing, reversed as per section, figure 13, *sixteen feet between supports.*

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
		Pounds.	*Pounds.*	*Inches.*	*Inches.*	Section of reversed beam.
1854.						
Dec. 21	1	2,240	2,240	.1875	0	
	2	2,240	4,480	.4375	0	
	3	2,240	6,720	.6562	.0312	
	4	2,240	8,960	.9062	.0312	
	5	2,240	11,200	1.3437	.2187	
	6	2,240	13,440	2.25	.7812	Ex. 6, R. No. 1.
	7	1,099	14,539	.....	.....	Ex. 7, R. No. 2.

Fig. 13.

Ex. 6, R. No. 1.—Beam took a sheer to the side of about one inch.
Ex. 7, R. No. 2.—Beam gave way laterally until the scales brought up on the ground. No sign of fracture.

EXPERIMENT No. 4.

Experiment on a girder of two beams, rivetted at their flanches, as per drawing, figures 5, 6, *and* 16; 18 *feet between supports.*

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
		Pounds.	*Pounds.*	*Inches.*	*Inches.*	Section.
1854.						
Dec. 21	1	1,240	1,240	Not taken.	Not taken..	
	2	1,740	2,980	.1875	.....do.....	
	3	6,201	9,181	.4375	.....do.....	
	4	4,480	13,661	.625	.....do.....	
	5	4,480	18,141	.8125	.....do.....	
	6	4,480	22,621	1.125	.....do.....	
	7	4,480	27,101	.....	.....	Ex. 7, R. No. 1.

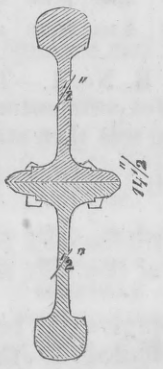

Fig. 16.

Ex. 7, R. No.—After having stood a moment the girder gave way laterally, bending sideways about two feet, until the weight was caught by the supports below. There was no sign of fracture. This girder would evidently have sustained a greater weight had it been confined, so as to prevent lateral motion; but the object was to show whether or not its construction would enable it to resist lateral flexure. It gave way with a weight of 27,101 lbs. Now, in Ex. Nos. 2 and 3, it will be seen that the separate beams gave way laterally with the weights respectively of 13,440 and 14,539 lbs.=27,979 lbs., showing but little difference in the beams to resist lateral flexure, whether they be used separately, or bolted together. It must, however, be borne in mind, that the girder was two feet longer than the beams, and that the beams composing it must necessarily have been somewhat weakened by the rivet-holes.

EXPERIMENT No. 5.

Experiment on the beam shown in figures 7 *and* 14, *the beam being reversed—that is, the additional plate was on top;* 16 *feet between supports.*

Date.	No of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
1855.		*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	Reversed beam.
Dec. 21	1	2,240	2,240	.125	0	
	2	2,240	4,480	.25	0	
	3	2,240	6,720	.375	0	
	4	2,240	8,960	.5937	0	
	5	2,240	11,200	.75	0	
	6	2,240	13,440	1.375	Not taken.	
	7	2,240	15,680	2.375	.....do.....	
	8	2,240	17,920	4.125	2.375	(Ex. 8, R. No. 1.)

Fig. 14.

Ex. 8, R. No. 1.—The beam having bent too much for use in a floor, the experiment was discontinued. There was no lateral flexure. The beam was then straightened and tried as per Ex. No. 6.

EXPERIMENT No. 6.

Trial of the same beam (figs. 7 and 14) with the additional plate below, as per drawing, figure 15.

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
1854.		*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	Section of beam.
Dec. 22	1	2,240	2,240	.1562	0	
	2	2,240	4,480	.3125	0	
	3	2,240	6,720	.4062	0	(R. No. 1.)
	4	2,240	8,960	.5937	.0312	
	5	2,240	11,200	.7812	.0625	
	6	2,240	13,440	1.2187	Not taken.	
	7	2,240	15,680	1.625	.....do.....	
	8	2,240	17,920	2.	.6562	

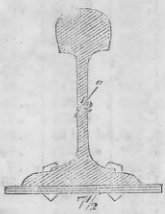

Fig. 15.

R. No. 1.—The increased deflection which is observed in these experiments over those on the same beam reversed, may be accounted for by the straining of the upper flanch of the beam, when it was subjected to the tensile strain of yesterday's experiments.

It is probable it is also due in some measure to the loosening and weakening of the rivets, in consequence of their being subjected to a different strain in this experiment, from that to which they were subjected yesterday. The increased strength of this beam, with the load of 7 and 8 tons, when the bottom flanch was below, seems to show that the greater quantity of metal should be in the lower flanch. This is contrary to all of Mr. Fairbairn's results, and I think other experiments should be made before we can arrive at conclusions on this point.

Experiment on a beam, as per drawing, figures 8 and 10.

It having been suggested that when the beams were confined by arches, the upper flanches could add but little, if any, to their strength, it was decided to build two arches as per drawing, Figs. 8 and 10, the upper flanch of the middle beam being planed off before the arches were constructed.

This opinion was founded on the supposed impossibility of any buckling of the upright web of the beam, when this web is confined to its place by good masonry.

These arches were therefore constructed, and the weights applied upon the brick work, immediately over the centre of the middle beam, as follows:

EXPERIMENT No. 7.

Experiment on a beam, as per drawing, figures 8 *and* 10; 19′ 5″ *between supports.*

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
1854.		*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	
Dec. 20	1	1,035	1,035	0	0	Section of beam, with top flanch planed off.
20	2	1,120	2,155	0	0	
20	3	1,120	3,275	.0625	Not taken.	
20	4	1,120	4,395	.0937	.....do.....	
20	5	1,120	5,515	.1562	.....do.....	
20	6	1,120	6,635	.25	.....do.....	
20	7	1,120	7,755	.2812	.....do.....	
20	8	1,120	8,875	.2812	.....do.....	
20	9	1,120	9,995	.375	.....do.....	
20	10	1,120	11,115	.4062	.....do.....	
20	11	1,120	12,255	.4375	.....do.....	
20	12	1,120	13,355	.5	.....do.....	
20	13	1,120	14,475	.5625	.....do.....	
20	14	1,120	15,595	.625	.....do.....	
20	15	1,120	16,715	.6875	.....do.....	
20	16	1,120	17,835	.75	.....do.....	
20	17	.....	17,835	.875	.4375	(Ex. 17, R. No. 1.)
20	18	.....	17,835	.875	Not taken.	(Ex. 18, R. No. 2.)
20	19	.....	17,835	1.0625	.....do.....	(Ex. 19, R. No. 3.)
21	20	.....	17,835	1.125	.....do.....	(Ex. 20, R. No. 4.)
21	21	1,120	18,955	1.25	.....do.....	
21	22	1,120	20,075	1.25	.....do.....	
21	23	1,120	21,195	1.25	.....do.....	
21	24	1,120	22,315	1.2812	.....do.....	
21	25	1,120	23,435	1.375	.....do.....	
21	26	1,120	24,555	1.375	.....do.....	

Fig. 10.

Ex. 17, R. No. 1.—After having stood five minutes, (weight, 17,835 pounds,) the deflection was .875″.

At this point all the weight was removed, and the beam showed a permanent deflection of .4375″.

Ex. 18, R. No. 2.—The same load was then reapplied, (17,835 pounds.) Deflection the same as before—.875″.

Ex. 19, R. No. 3.—After having stood two hours, (weight, 17,835 pounds,) the deflection was 1.0625″.

Ex. 20, R. No. 4.—After having stood all night, the deflection was 1.125″, (weight the same, 17,835 pounds.)

At this stage of the experiment it was discovered that the two side beams supporting the arches had also deflected, showing that the arches had transmitted a part of the weight to them which had been intended to be applied only to the central beam.

It was very cold weather. Everything was frozen; and the arches, being laid in good cement, might be regarded as a single stone, possessing, of course, some flexibility, but bearing upon all three of the beams; and as the middle beam settled, this stone, in conjunction with the iron straps shown on the drawing, (No. 8, strap C,) transmitted the weight to the outside beams. There was no visible sign of cracking in the arches.

The deflections of the outside beams were, respectively, left hand, .5625″, right hand, .4375″.

After these measurements were taken, the keys of these straps were loosened, and the arches began to settle immediately at the middle of the centre beam.

They went down slowly to a deflection of four inches, when the ends of the beams supporting the table upon which the load was applied, were brought down in contact with the arches.

It was the middle beam which settled—the arches following and cracking considerably.

The fibres of the lower flanch of the central beam were evidently stretched.

Experiment on a beam, as per drawing, figs. 8 *and* 9.

This experiment was intended to show whether the upper flanch was or was not necessary when the beams were confined by masonry, as stated in the last experiment.

Two arches were therefore constructed, in all respects similar to the foregoing, the upper flanch of the middle beam *not* being planed off.

EXPERIMENT NO. 8.

Experiment on a beam as per drawing, figures 8 *and* 9; 16 *feet between supports.*

Date.	No. of experiment.	Weight added.	Total weight applied.	Deflection.	Permanent deflection; weight removed.	Remarks.
		Pounds.	*Pounds.*	*Inches.*	*Inches.*	
1854.						Section of beam.
Dec. 20	1	1,008	1,008	0	0	
20	2	1,120	2,128	0	0	
20	3	1,120	3,248	0	0	
20	4	1,120	4,368	0	0	
20	5	1,120	5,488	0	0	
20	6	1,120	6,608	0	0	
20	7	1,120	7,728	0	0	
20	8	1,120	8,848	.0625	0	
20	9	1,120	9,968	.0625	Not taken.	
20	10	1,120	11,088	.0625	....do.....	
20	11	1,120	12,208	.0937	....do.....	
20	12	1,120	13,328	.1875	....do.....	
20	13	1,120	14,448	.25	....do.....	
20	14	1,120	15,568	.3125	....do.....	
20	15	1,120	16,688	.3125	....do.....	
20	16	1,120	17,808	.3437	....do.....	
20	17	1,120	18,928	.375	....do.....	
Dec. 21	18	.....	18,928	.....	.25	(Ex. 18, R. No. 1.)
21	19	1,120	20,048	.8125	Not taken.	(Ex. 19, R. No. 2.)
21	20	1,120	21,168	.8125	....do.....	
21	21	1,120	22,288	.875	....do.....	
21	22	1,120	23,408	.937	....do.....	
21	23	1,120	24,528	1.	....do.....	
21	24	1,120	25,648	1.125	....do.....	(Ex 24, R. No. 3.)
21	25	.....	25,648	1.5625	....do.....	(Ex. 25, R. No. 4.)
Dec. 21, 5 p. m.	26	.....	25,648	2.125	....do.....	
Dec. 22, 11 a. m.	27	.....	25,648	3.125	....do.....	
Dec. 23, 5 p. m.	28	.....	25,648	3.875	....do.....	(Ex. 28, R. No. 5)

Fig. 9.

Ex. 18, R. No. 1—December 21.—This morning the load on the table was found to have fallen down on the arches during the night. It was all removed, and the permanent deflection of the centre beam was .25″. It was then all replaced, and 1,120 pounds were again added, (weight, 20,048 pounds.)

Ex. 19, R. No. 2.—This great increase of deflection was no doubt caused by the shock of the weight, (18,928 pounds,) which fell from the table on the arches.

Ex. 24, R. No. 3.—The side-beams were here examined, and it was found that they had deflected, respectively, left hand .3125″, right hand .25″, showing that the arch, together with the ties, had transmitted the weight to them as in the former experiment.

Ex. 25, R. No. 4.—The keys of these ties were then loosened, when the middle beam showed a deflection of 1.5625″.

Ex. 28, R. No. 5.—After this last experiment, the fibres of the lower flanch of the middle beam were evidently stretched, and the experiment having been carried far enough to show the necessity of the upper flanch of the beam, it was discontinued.

The necessity of the straps to connect the iron beams is conclusively shown in this, as well as in the former experiment.

All of which is respectfully submitted.

B. S. ALEXANDER,
Lieutenant Corps of Engineers.

WASHINGTON, D. C., *January* 22, 1855.